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INFORMATION INTEGRATION TECHNOLOGY DEMONSTRATION (IITD)

PAR Government Systems Corporation

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13. ABSTRACT *(Maximum 200 words)*

The objectives of the Information Integration Technology Demonstration (IITD) were to investigate, design a software architecture and demonstrate a capability to display intelligence data from multiple disciplines. Intelligence information can be obtained from any sources, including but not limited to, Imagery, Electronic, and Signal Intelligence (IMINT, ELINT, SIGINT). During the course of the program, a variety of existing Government-Off-The-Shelf (GOTS) and Commercial-Off-The Shelf (COTS) information exploitation systems were evaluated. Existing multi-source intelligence information sources and user requirements were also assessed. The ArcView Geographic Information System (GIS), developed by ESRI, was chosen as the baseline COTS application for IITD. A variety of information sources were incorporated into demonstration projects during the program. Special purpose scripts were developed to modify the ArcView graphical user interface and to extend the system's capabilities. Demonstrations to DOD customers, including the 480th and the National Air Intelligence Center (NAIC) were performed under the effort.

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1 INTRODUCTION

This Final Technical Report (FTR) summarizes the work accomplished during the performance of Air Force Research Laboratory (AFRL) contract F30602-98-C-0031 entitled Information Integration Technology Demonstration (IITD). The objective of the IITD program was to investigate, design, and implement a software architecture that demonstrates the capability to synergistically display, or visualize, multi-source intelligence information.

During the course of the program, a variety of existing Government-Off-The-Shelf (GOTS) and Commercial-Off-The-Shelf (COTS) information exploitation systems were evaluated. Existing multi-source intelligence information sources and user requirements were also assessed. The ArcView Geographic Information System (GIS), developed by ESRI, was chosen as the baseline COTS application for IITD.

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2 ACCOMPLISHMENTS

Under the IITD program, four technical tasks were performed to accomplish the program objectives. The first task was a requirements analysis. The analysis was comprised of an evaluation of existing software systems, an examination of multi-source intelligence information sources, and an assessment of intelligence analyst requirements.

The second task focused on specifying an architecture design for the IITD system. ESRI's ArcView geographic information system (GIS) was chosen as the most technically feasible, low risk, and cost effective approach for developing the baseline architecture. The GIS architecture best met the IITD derived requirements.

The third task was the testbed implementation. The task involved primarily data and application integration. Resources were focused on selecting and integrating a variety of information sources. The implementation goal was to develop exploitation techniques and methods for automating the building of ArcView projects in support of an intelligence production environment.

The final task focused on the development of demonstrations showing the ability to integrate a variety of intelligence data sources supporting multi-source visualization methods.

2.1 IITD Requirements

During the requirements analysis, the IITD team identified, investigated, reviewed, and assessed previous work that had been performed in the areas of data visualization and

data/information integration. An assessment was performed on each software application to determine its features, benefits, limitations, reusability, and value-added potential. The assessment was accomplished by reviewing technical product specifications (documentation) and actually exercising the software.

2.1.1 COTS/GOTS Applications Review

To the maximum extent possible, the COTS/GOTS assessment was based upon usage and exercise of the software products. An assessment of current trends in information storage and computer software architectures was also performed. Multi-source information data sets were acquired such that a realistic demonstration of system capabilities could be performed. From the investigation, a derived set of the functional, performance, data, interface, and operational requirements for the IITD visualization testbed was developed.

The applications evaluated are summarized in Table 1. Note, most of these applications were installed and evaluated in the AFRL/IFEC Imagery Exploitation (IE) 2000 facility.

Table 1. Software Applications Evaluated

Application	Capability
Gold Dust	Demonstrational system presents 3-D representations of targets superimposed on maps and/or images.
ClearSpace	Java-based components used for viewing and editing maps, CAD drawings, and graphics.
Joint Mapping Toolkit (JMTK)	An on-going program sponsored by NIMA. JMTK consists of an architecture and set of functions that support mapping functionality.
The Multi-image Exploitation Tool (MET)	Multi-sensor imagery toolkit for the analyst. Designed to perform imagery registration and comparison analysis (or measurements) from images from multiple sensors.
Image/J	Java implementation of an image display system. It is capable of displaying a variety of image formats, each displayed separately in its own window.
ERDAS Imagine	An extensive system for image display, manipulation, and exploitation.
ArcView	A Geographic Information System (GIS) that supports: visualization tools, ingesting of data, a spatial analyst, and a track analyst.
Map Objects	Provides software components for building an Internet-based Geographical Image Server.
OILSTOCK	Designed to display track data on a map background in real time or from archives.
Vitec ELT	A set of imagery exploitation tools to support the image analyst.

An investigation into web-based development tools for the IITD application was also performed. The availability of software development tools that could support the development and integration of a web-based visualization environment was investigated. Unfortunately, web-based development tools have not matured enough for true visualization requirements. Research into existing Web browser Common Gateway Interfaces (CGIs) and plugins was performed. No existing components were available commercially or in shareware that satisfied the imaging and cartographic requirements. Development environments based on JAVA or the TCL toolkit were also researched, but the magnitude of a development effort would be substantial.

2.1.2 System Requirements

System requirements were derived for IITD. Most of these requirements were satisfied in the IITD demonstrational system. The derived requirements are summarized in Table 2.

Table 2. IITD Derived Requirements

Requirement	1st Tier Functionality	Detailed Functionality
1. Provide multiple database access	Incorporate standard NIMA products.	ADRG, DTED, VMAP, CIB
	Incorporate Intel Reports	EOB, ELINT, IPIR
	Incorporate Commercial Data	Imagery and maps
2. Support multi-INT data display	Base Map Display with Symbols	Provide legend for symbols Allow for symbol interrogation Associate all data types through point and click
	Integrated common view of diverse information types	Provide capability to geo-register multi-INT data Sensor footprint on maps linked to sensor imagery Drape imagery over 3D DTED surface Provide rapid viewpoint change for 3D displays (pan, tilt and zoom) Provide capability to display symbols on a 3D surface Access all data types through point and click on symbols on 3D surface
3. Demonstrate selected geospatial queries	Query multi-INT data stores	List all selected reports within a specific distance of a feature List all imagery of specified type that covers selected point or feature List all EOB or ELINT reports within specified distance of selected point or feature Line of sight from selected point Display terrain profile through selected point Proximity to populated areas Show radar coverage for selected ELINT sites:

		Circular coverage Circular coverage with terrain masking
4. UAV video exploitation	Display center points of video stream	Provide for geospatial queries on sensor track Permit video frame selection based on GIS queries Display all frames near selected feature
	Display video sequence	Start, Stop, Pause, Fast Forward, Reverse
5. IITD GUI	Focus on a single window for display	
	Add icons to the toolbar to perform common tasks	Pop up to top level of country map Zoom to selected data type Display selected object metadata
	Provide a limited set of menu items	Open project Open views Show theme Make theme active Check for availability of new data items/reports Incorporate new data items/reports Perform geospatial queries Select data presentation format/view Interactive display
6. Long Term Plans	Interface to existing data servers	Image Product Library

2.2 IITD Architecture

The design objectives were derived from the system requirements and assessment of existing COTS/GOTS data visualization and integration applications. A trade-off analysis was performed to select the most effective design approach for developing an architecture that meets the derived requirements at reasonable cost and risk. The result of this analysis evolved into the decision to use a COTS geographical information system (GIS) as the core system. Specifically, ArcView GIS was chosen as the GIS for the IITD development. ArcView effectively supports visualization of multiple layers of geographically registered information. ArcView also supports geographic and relational query of the information that is maintained in its database. ArcView is commonly used in DoD agencies such as the National Imagery and Mapping Agency (NIMA). The ArcView GIS capabilities are fully documented in the IITD Software Architecture Document.

The operational environment that the IITD system is designed to operate within is shown in Figure 1. IITD assumes that finished intelligence information is available over a network such as SIPRNET (secure Internet-protocol router network). How the intelligence information is derived from the sensor data is outside the scope of the IITD data integration and visualization requirements. Other DoD programs are focusing on automated processing of sensor data into completed intelligence. IITD ingests intelligence information through standardized intelligence reporting formats.

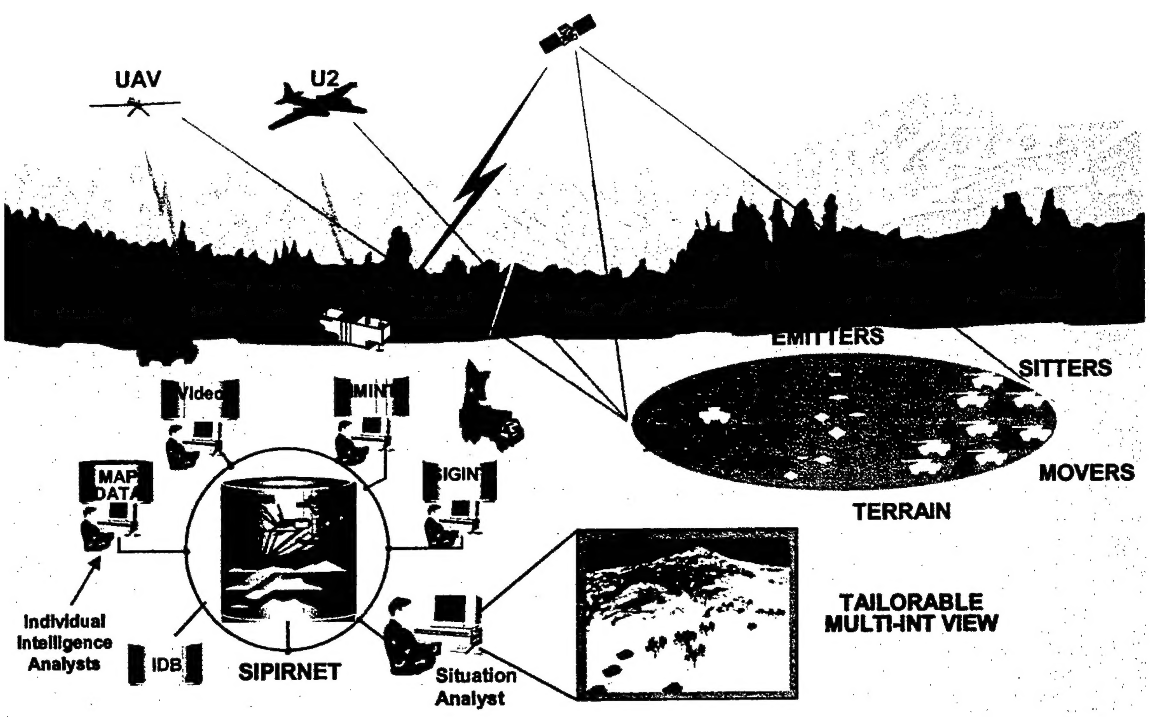

Figure 1. IITD Operational Environment

Figure 1 shows each sensor data stream being processed by a single source intelligence analyst (i.e., image analysts). The IITD objective is to integrate these various intelligence sources into a common multi-INT environment for display and exploitation by a multi-source situation analyst. IITD accesses a variety of intelligence information sources in standardized formats to produce a common scene-registered display, and to support manipulation and exploitation of the data.

The IITD system (Figure 2) consists of a core system based on the ESRI ArcView. IITD uses ArcView extensions to support image display, target tracking, and spatial/3D analysis. The basic ArcView capability supports the import of standard image formats. IITD can also ingest NITF (National Imagery Transmission Format), ADRG (Arc Digitized Raster Graphic), CADRG (Compressed Arc Digitized Raster Graphic), CIB (Controlled Image Base), and DTED (Digital Terrain Elevation Data) files. Additional input filters were developed to ingest ELINT reports and other text reports.

2.3 IITD Software Development

Software development on the IITD program was concentrated in two areas involving (1) developing ArcView AVENUE scripts, and (2) prototyping an export capability of multiple GIS layers to NITF. The primary concentration for the program was in the development of the AVENUE scripts. Development of the NITF export capability was limited due to the proprietary nature of the ArcView internal architecture.

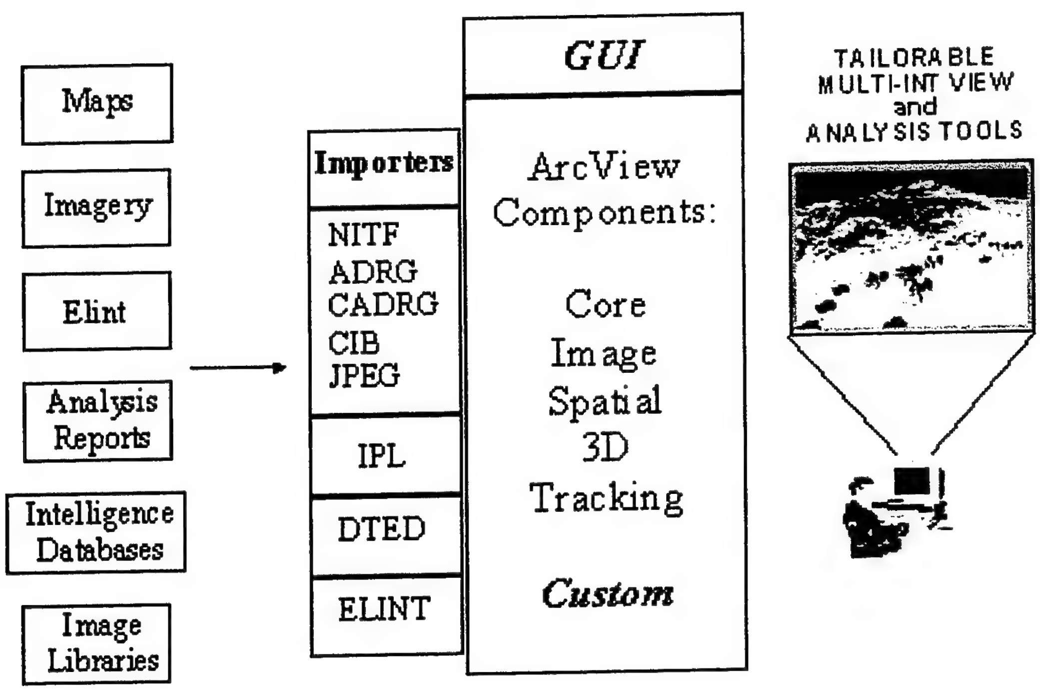

Figure 2. Components of the IITD Architecture

The need to add functionality to the ArcView GIS resulted from mapping existing ArcView functionality to the IITD requirements list. The existing ArcView user interface that supported interaction with multiple layers of information, although very flexible, was not conducive to allowing an intelligence analyst to streamline a production flow. The need also existed to query and ingest products from intelligence databases that are relational in nature. In fact, a direct connection to the Sybase relational database system (RDBMS) was required. To accomplish these enhancements within the IITD system, the ESRI AVENUE scripting language was used to modify the user interaction with ArcView and support ingest of intelligence information into the ArcView data management schema. AVENUE was also used to produce a tool set to perform a variety of non-standard (additions to ArcView) multi-INT processing procedures.

The IITD user interface was developed to mimic existing intelligence production environments. The major difference between the ArcView standard interface and the IITD AVENUE based user interface script is the ability to perform operations in a procedural nature. The ArcView native interface supports unrestricted loading of information through menus and icons. The user must have knowledge of where data is located (on the disk or network), and in which layers the information will be displayed. Under IITD, a script was developed to allow the analyst to load a project, or collection of information, using country code or target basic encyclopedia (BE) number to select the information to be displayed. The major change to the standard ArcView GUI was to utilize a single window for display. The standard ArcView approach is to pop up a new window at every request for a display. Using a single display window provides a more integrated approach. Requests for a new display result in replacing the currently displayed image.

The ability to effectively use symbols for imagery coverage and electronic order of Battle (EOB) information was also performed through the scripting language. The functionality to allow the user to specify scale and dynamically have the best resolution map and imagery information display over the selected target area was also supported through AVENUE scripts. Ingest of track data, collected from Oil Stock, into IITD was additional functionality added using the scripting language.

The following list summarizes the additions and modifications made to the ArcView GUI:

1. A single display window approach was implemented. (ArcView generally pops up a new window for each data type selected.),
2. The display varies with the selected resolution. (The optimal ADRG is displayed based on the resolution selected by the user.),
3. Attached scripts to events to provide access to metadata. (An event is an object in ArcView. It can be a variety of objects such as a symbol on an image or map, an image, a map, an overlaid shape etc.),
4. Provided a capability to update ArcView metadata tables with new information,
5. Making the display reflect the updated table information,
6. Embedding scripts,
7. Using data from a table in a dialog display,
8. Using a dialog display to enter data in a table,
9. Customizing the Menu/Button/Toolbar look,
10. Determining what type of scripts to attach to dialog boxes,
11. Developed scripts including click event, activate event and update event,
12. Customizing the legend with symbols, colors, sizes etc.,
13. Aligning images. (ArcView has the capability of registering objects to a common geographical coordinate system.), and
14. Adding graphics to GIS shape files. (A shape file is an ArcView GIS data set used to represent a set of geographic features. Shape files support point, line, and area features. A shape file has a vector data structure and links spatial data with attribute data.)

An ArcView tool was developed to allow automatic ingesting of images. The tool automatically loads the image, makes a table of the image geographic boundary, and adds the entries to the existing image catalog table.

2.3.1 NITF Export

One of the problems associated with exploiting diverse information types is the amount of effort required to bring all of the information into a common application such as ArcView. There are numerous requirements for processing Multi-INT data, and each analyst is faced with the tedious job of creating their own database. An ability to archive IITD projects using the NITF standard was investigated under this program. The capability to permit diverse users to start with an entire set of standard data over a target area that is ready to be exploited or used for operations planning was desired. The user would only need to import mission specific data items in order to be productive. The minimum content for this class of user would be equivalent to NIMA's prototype

Foundation Data (DTED, CIB, VMAP). The concept of saving all of the data in an ArcView project in a multi-component NITF file was investigated under the program but not implemented. These archived projects could be stored as intelligence data in a server such as the Image Product Library (IPL). Data in the NITF file would include imagery such as CIB, terrain data such as DTED, map data such as ADRG, and VMAP. Historical ELINT reports would also be stored. The objective of the NITF export capability was to create a complete archive of geo-registered data to serve as a base for supporting new missions.

Generating a prototype NITF format required defining a protocol that captured all of the information associated with an ArcView project. Some of the information (such as geographical coordinates of images and items identified in images) would be saved as metadata. Images would in general be saved in their original input format; thus, permitting users who do not have access to an IITD system or ArcView to read the images using other tools.

Generating an NITF archive file presented a number of insurmountable challenges that prevented the NITF export capability from being implemented. ArcView uses a proprietary format for internally storing images. The internal format can only be read by a few applications beside ArcView; thus, the internal format is not an acceptable archiving format as data conversion is necessary. Another problem was that AVENUE does not support binary mode file I/O. As a work around, a dynamically linked library (DLL) was developed in C++ to perform file I/O. However, in order to archive an ArcView project, access to the project's table of contents and paths to the objects in the project is required. Unfortunately ArcView does not provide external access to such information. AVENUE has limited access to ArcView internal parameters and does not have access paths to data files.

2.4 IITD Demonstrations

Three primary demonstrations were developed and supported during the IITD program. The demonstrations addressed three exploitation objectives that included: multi-source intelligence exploitation, UAV tracking, and multi/hyperspectral imagery exploitation. The multi-source demonstration utilized data resident in the AFRL/IE2000 for a scenario in Korea. The UAV track demonstration utilized a Hunter UAV collection at Elgin AFB. The multi/hyperspectral imagery demonstration utilized data collected over Fort Drum, NY. Additionally, data was obtained and added to the IITD system for scenarios in Kosovo, Syria, and a proposed exercise in the CONUS.

The demonstrations were given in the AFRL/IE2000 facility. A demonstration and technology exchange were also performed with the fusion group located at the National Air and Intelligence Center (NAIC). The IITD demonstration was performed on a Windows NT server in the IE2000, and supported on a portable laptop running Windows NT.

3 CONCLUSIONS AND RECOMMENDATIONS

The Information Integration Technology Demonstration (IITD) program has clearly demonstrated that there are considerable benefits to integrating information in a common exploitation environment. Furthermore, under the IITD program it was demonstrated that the choice of the ArcView GIS system provided the most robust capability in terms of rapidly and cost effectively producing a prototype integrated information exploitation system. During the final months of the IITD development, a similar ArcView development program was sponsored by NIMA called NIMA-in-a-BOX. The program scope was to make ArcView modifications to allow generation of hardcopy output in support of flight operations. NIMA, ERIM, and ESRI developed the product. This system consists of the ArcView GIS software together with a set of ArcView scripts, a graphics workstation, and a disk storage scheme required to support the NIMA databases.

Although the IITD development using the ArcView system provided a cost effective and rapid prototype, the architecture does not support a robust standards specification to allow intelligence archives to readily be integrated, or ingested, into its internal data structures. An open architecture that is modular and allows straightforward integration through standardized interfaces needs to be developed. The user interface for query of information needs to be web-centric. The intelligence data needs to remain as close to native format as possible, and the visualization environment needs to be adaptable to support 2D and 3D viewing. A recommended architecture is shown in Figure 3.

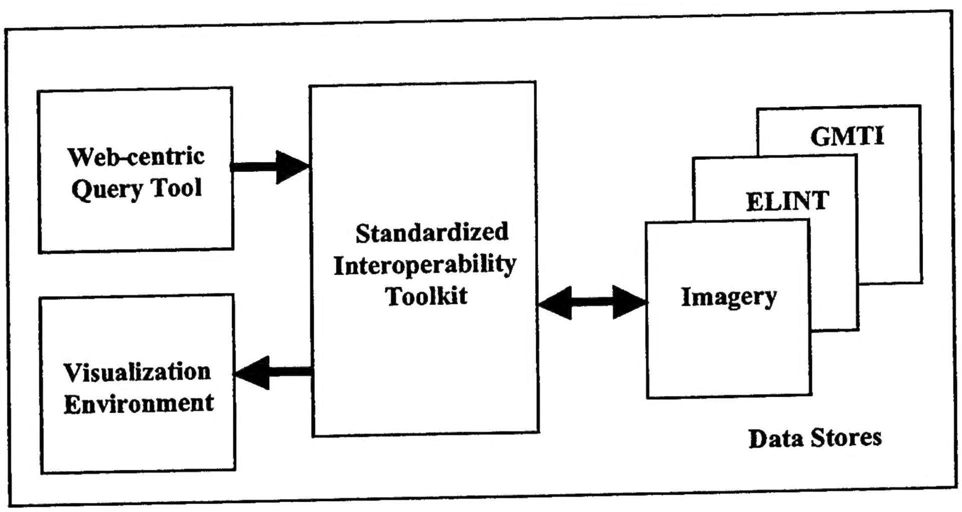

Figure 3. Interoperability Architecture

AFRL/IF is performing on-going work in the development of a general three-dimensional visualization framework. The capability is called JVIEW. The visualization environment is based on JAVA and JAVA 3D. The JVIEW capability was originally developed to support modeling and simulation, but has been generalized to support visualization of various data representations. This visualization environment has been developed as layers that include facilitators and oddments. Facilitators provide the baseline capabilities to support 3D data manipulation and rendering, geo-location, data display, etc. Oddments are user defined or developed tools that support application specific requirements.

Oddments may be dynamically added and removed from a JVIEW environment that is actively running. Additional facilitators and oddments need to be added to the JVIEW environment to accurately support geo-location requirements of an intelligence information system.

The interface between the exploitation environment and the actual intelligence data stores needs to be standardized such that existing and new data stores may be readily interfaced to a user's work environment such that web-centric query and visualization components can readily support integrated display of information. The interface will actually be comprised of software based solutions such as gateway services (and portals), publish and subscribe techniques, or object request broker services. Standards that will work within these software solutions must include interface definition languages or libraries such as those published and supported by the NIMA (i.e., Geo-spatial Imagery Access Services [GIAS] specification) or the Open GIS Consortium (i.e., Open GIS Web Map Server Interface Implementation Specification).

It is suggested that work be extended to research and enhance the existing NIMA GIAS specification to support profiles for new data types such as electronic data (i.e., ELINT) or radar ground moving target data (i.e., GMTI). It is also suggested that a common object request broker architecture (CORBA), using a commercial object request broker (ORB), be utilized to demonstrate the integration of intelligence data stores through an enhanced GIAS model to support query of intelligence information and actual display through a visualization tool such as the AFRL JVIEW. Map information may be effectively integrated utilizing an OPEN GIS map server implementation.

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